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(56) Documents cited
GB 2148488 A GB 1458274 A EP 0227136 A1
WO 90/09560 A1

(58) Field of search
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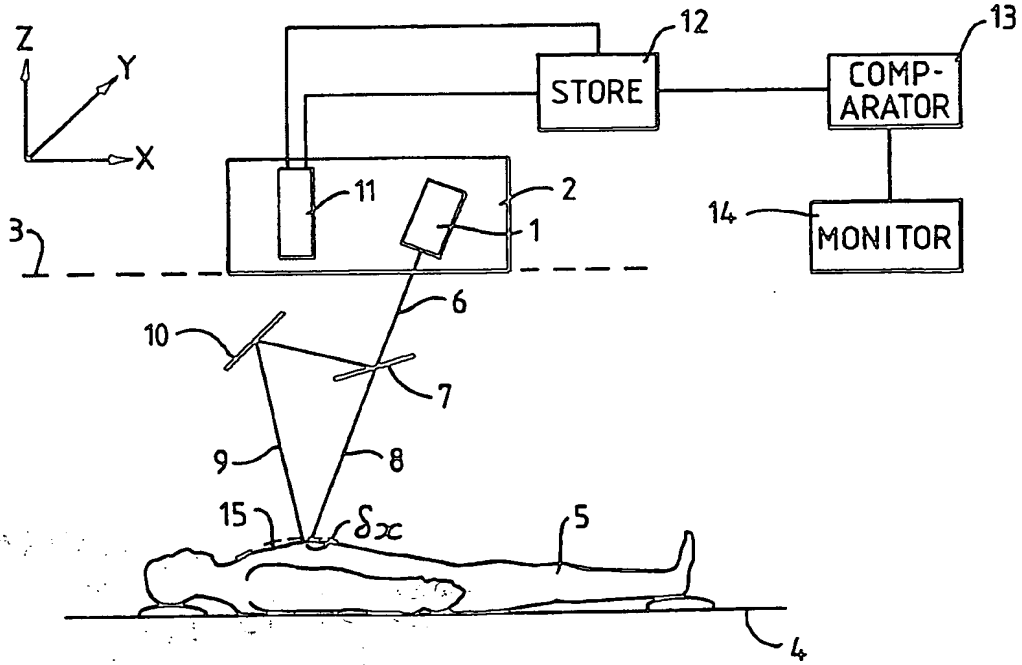
INT CL[5] G01B, G01C, G01S

(54) Displacement monitoring system using two light beams

(57) A method of and apparatus for detecting movements of a surface (15) of a body (5) in which two beams of light (8, 9) are directed at the body (5) at an angle to each other and changes in their separation (δx) where they impinge on the body are monitored to detect changes in the position of the body (5) relative to a reference plane (3). The system may comprise of a single laser (1) arranged to supply two infra-red radiation beams (8, 9) which can be modulated to avoid interference. The system may be scanned in two dimensions within the plane normal to that of the two radiation beams and the signals processed for assessing relative displacements.



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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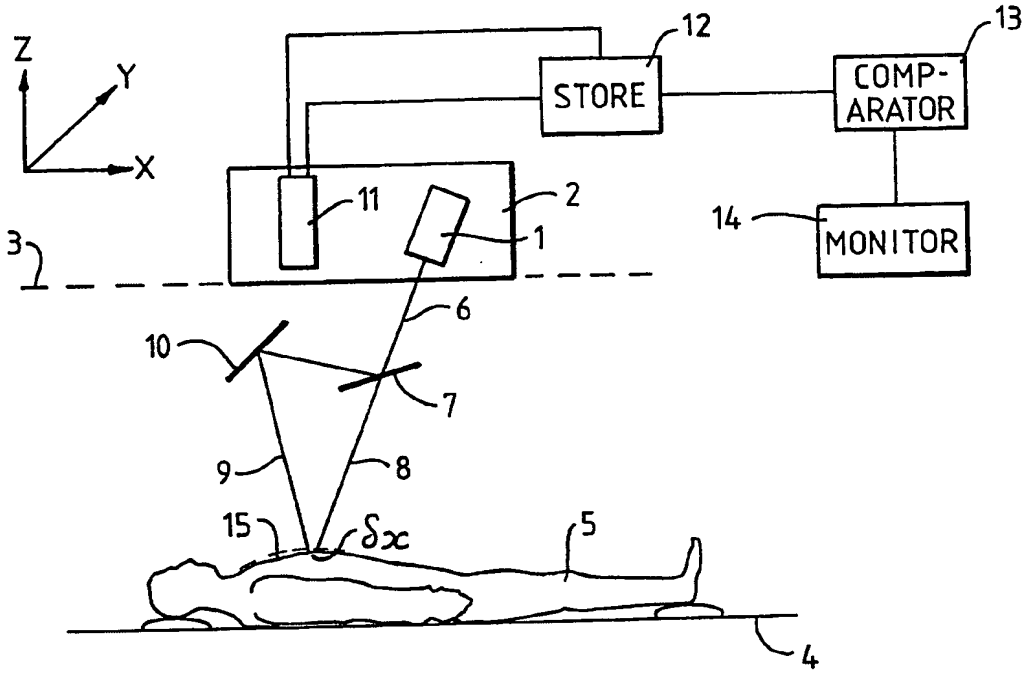
Z
Y
X
STORE
12
COMP-
ARATOR
13
11
2
1
3
14
MONITOR
6
10
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9
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δx
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4

The Monitoring of Displacements

The present invention relates to the monitoring of displacements and more particularly to monitoring displacements due to changes in physical parameters such as the size, configuration or position of a solid body.

A number of circumstances can arise in which it is necessary to monitor displacements due to changes in the size, configuration or position of a solid body. For example, one may wish to monitor deflections of a beam or the wall of a pressure vessel under load, or the breathing or position of a sleeping or otherwise unconscious person.

Many methods exist for carrying out such an operation ranging from contact probes to interferometric methods. It is an object of the present invention to provide a method of, and apparatus for, monitoring displacements of a body, which are non-contacting and unobtrusive.

According to the invention there is provided a method of monitoring displacements of a surface of a body comprising the operations of establishing a reference plane with respect to a body displacements of a surface of which are to be monitored, directing two beams of light at the body at an angle to each other, determining the separation between the points at which the two beams are incident upon the body and detecting temporal changes in the separation of the two positions at which the beams of light are incident upon the body thereby to monitor displacements of the surface of the body.

Also according to the invention there is provided an apparatus for monitoring displacements of an element of a

surface of a body, comprising means for producing two beams of light and projecting them at an angle to each other onto an element of a surface of a body displacements of which are to be monitored, means for measuring the separation between the positions on the body at which the two beams of light are incident to determine a measure of the distance between the element of the surface of the body and a reference plane associated with the body, means for detecting temporal changes in the separation between the positions at which the two beams of light are incident upon the element of the body to determine displacements of the element of the surface of the body and means for indicating the displacements of the surface of the body.

Preferably there is included means for repeatedly scanning the two beams of light over the surface of the body in a direction normal to the line joining the positions at which the two beams of light are incident upon the surface of the body, the scanning means being adapted to move in the said reference plane, means for storing data relating to the measurements made during one scan of the separation between the positions at which the two beams of light are incident upon the body, means for comparing the stored data with corresponding data acquired in a succeeding scan of the beams of light over the body and means for providing an indication of any differences between the compared data thereby to monitor displacements relating to the body.

Displacements relating to a body which can be monitored by the present invention include changes in the size, configuration or position of the body.

The invention will now be explained and described, by way of example, with reference to the accompanying

drawing which is a diagrammatic representation of an apparatus for monitoring the movements of the body of a sleeping person.

Referring to the drawing, a laser source 1 of infra red radiation is mounted upon a carriage 2 which is adapted to be moved, by means not shown, in a plane 3 (x,y) a distance z above a bed 4 upon which is a person 5. The output beam 6 from the laser 1 is divided by a beam splitter 7 and formed into two beams 8 and 9. The beam 8 is directed directly at the person 5 and the beam 9 is directed also at the person 5 by means of a mirror 10. The beams of light 8 and 9 are arranged to converge at an angle θ, but to be separated by a distance δx where they impinge upon the body of the person 5. A position sensing detector 11 is arranged to observe the position where the beams of light 8 and 9 are incident upon the person 5 and produce data signals related thereto. The data signal from the detector 11 are applied to a store 12, a comparator 13, and thence to a monitor 14. Also applied to the store 12 are signals related to the position of the carriage 1 in the reference plane 3.

The separation δx between the points where the beams 8 and 9 impinge on the body of the person 5 is a function of the angle θ and the distance z between the upper surface 15 of the body of the person 5 and the reference plane 3.

Assuming the scan of the carriage is regular, the co-ordinates (x,y) of any given point 0 in a complete scan of the carriage 2 in the (xy) plane 3 between limits $x = 0 \rightarrow X$ and $y = 0 \rightarrow Y$ can be deduced from measurements of the time which has elapsed from the beginning of a scan only, as follows:-

let t_1 = the time taken for each complete scan of the beams of both 8 and 9 in the y-direction,

δt = the time taken for the beams 8 and 9 to reach 0 in the y-scan in which it occurs,

t_2 = the time taken from the beginning of the total scan for the beams 8 and 9 to reach the position 0,

n = the number of complete y-scans to reach the position 0,

T = the total time taken to complete a scan field ($x = 0 \rightarrow X$, $y = 0 \rightarrow Y$), and

N = the total number of y-scans in a scan field.

We have $t_2 = (n\ t_1 + \delta t)$, therefore $\delta t = t_2 - nt$,

and $$x = [\frac{n}{N}]X, y = [\delta \frac{t}{t_1}]Y$$

As the person 5 breathes and his chest rises and falls, the separation δx will change in a regular way. Changes in the condition of the person 5 can be monitored by storing in the store 12 the changes in the separation δx which occur during one complete breathing cycle and comparing the stored data with later acquired data. Movement of the body of the person 5 can be monitored by scanning the carriage 2 in the y-direction, storing data related to the changes in δx as the light beams 8 and 9 are scanned over the body of the patient 5, and comparing data from one scan with data from a succeeding scan. Whole body movement can be detected by scanning the carriage 2 in the x-direction as well as the y-direction and carrying out similar storage and comparison operations as before.

In order to distinguish between the image spots of

the beams 8 and 9 and to avoid possible extraneous interference effects one or both of the beams 8 and 9 can be modulated.

When the body being monitored is a human being, as described above, it is preferable that the laser 1 is a low powered infra-red laser. It may be operated in either a continuous or pulsed mode.

Claims

1. A method of monitoring displacements of a surface of a body comprising the operations of establishing a reference plane with respect to a body displacements of a surface of which are to be monitored, directing two beams of light at the body at an angle to each other, determining the separation between the points at which the two beams are incident upon the body and detecting temporal changes in the separation of the two positions at which the beams of light are incident upon the body thereby to monitor displacements of the surface of the body.

2. A method according to Claim 1 wherein the displacements of the surface of the body are due to changes in the size, configuration or position of the body.

3. An apparatus for monitoring displacements of an element of a surface of a body, comprising means for producing two beams of light and projecting them at an angle to each other onto an element of a surface of a body displacements of which are to be monitored, means for measuring the separation between the positions on the body at which the two beams of light are incident to determine a measure of the distance between the element of the surface of the body and a reference plane associated with the body, means for detecting temporal changes in the separation between the positions at which the two beams of light are incident upon the element of the body to determine displacements of the element of the surface of the body and means for indicating the displacements of the surface of the body.

4. Apparatus according to Claim 3 wherein there is

included means for repeatedly scanning the two beams of light over the surface of the body in a direction normal to a plane in which the two beams of light lie, the scanning means being adapted to move in the said reference plane, means for storing data relating to measurements made during one scan of changes in the separation between the positions at which the beams of light are incident upon the body, means for comparing the stored data with corresponding data acquired in a succeeding scan of the beams of light over the body and means for providing an indication of any differences between the compared data sets thereby to monitor displacements of the surface of the body.

5. An apparatus according to Claim 4 wherein the scanning means is adapted to raster scan the two beams of light over an area of the body extending perpendicularly to the first direction of scan of the two beams of light over the surface of the body.

6. An apparatus according to any of Claims 3 to 5 wherein the two beams of light are derived from a single source.

7. An apparatus according to any of Claims 3 to 6 wherein at least one of the beams of light is modulated thereby to prevent optical interference between the two beams of light.

8. An apparatus according to any of Claims 3 to 7 wherein the two beams of light have a wavelength in the infra-red region of the electromagnetic spectrum.

9. An apparatus according to any of Claims 3 to 8 wherein the beams of light are beams of laser radiation.

10. A method for monitoring displacements of a surface of a body substantially as hereinbefore described and with reference to the accompanying drawing.

11. An apparatus for monitoring displacements of a surface of a body substantially as hereinbefore described and with reference to the accompanying drawing.

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

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E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family, corresponding document.

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